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Femoral Avulsion of the Medial Patellofemoral Ligament After Primary Traumatic Patellar Dislocation Predicts Subsequent Instability in Men

A Mean 7-Year Nonoperative Follow-Up Study

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Background: The clinical relevance of medial patellofemoral ligament (MPFL) injury location in primary patellar dislocation has not been studied.

Hypothesis: Prognosis after primary traumatic patellar dislocation may vary by MPFL injury location.

Study Design: Cohort study; Level of evidence, 3.

Methods: The initial magnetic resonance imaging (MRI) findings in 53 patients with identical nonoperative management were retrospectively analyzed for medial restraint injuries. The MPFL injury sites were classified as follows: femoral, midsubstance, and patellar. Magnetic resonance imaging was used to assess initial and control articular cartilage lesions in the patellofemoral joint. After a mean follow-up of 7 years, 42 patients were evaluated for redislocations, subjective symptoms, and functional limitations.

Results: Based on the initial MRIs, MPFL rupture was classified as femoral in 35 patients, midsubstance in 11, and patellar in 7. At follow-up, 15 patients reported an unstable patella (13 femoral, 1 patellar, 1 midsubstance; $P = .01$) and 9 reported patellar redislocations (8 femoral, 1 midsubstance; $P = .05$). The proportion of patients who regained their preinjury activity level was significantly smaller among those with femoral MPFL injury than among those with midsubstance or patellar MPFL injury ($P = .05$). The median Kujala score was as follows: 90 for femoral, 91 for patellar, and 96 for midsubstance ($P = .76$). Control MRI showed full-thickness patellofemoral cartilage lesions in 50% of the patients, unrelated to MPFL injury location.

Conclusion: An MPFL avulsion at the femoral attachment in primary traumatic patellar dislocations predicts subsequent patellar instability. The authors suggest that MPFL injury location be taken into account when planning treatment of primary traumatic patellar dislocation.

Keywords: patella; dislocation; medial patellofemoral ligament; knee; injury

In the patellofemoral joint, the medial structures preventing lateral displacement of the patella include the superficial medial retinaculum and the medial patellofemoral ligament (MPFL), the patellotibial ligament, and the patellomeniscal ligament.[13] According to biomechanical cadaveric studies,[7,9,16] the MPFL acts as the major ligamentous restraint against lateral patellar dislocation. In 1979, Warren and Marshall[36] delineated the MPFL as an extracapsular structure of layer 2 of the medial aspect of the knee, outside the synovium. Based on the dissection of 154 fresh-frozen cadavers, their description revealed only minor anatomical variations in the medial structures of the knee. In the literature, the MPFL is thus considered a thickening of the medial retinaculum,

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always present but with considerable variation with respect to the size and thickness.[7,9,16,28] The MPFL extends from the superior medial border of the patella (at approximately the 2- to 4-o'clock position on a right knee), and it attaches firmly to bone between to the adductor tubercle and the medial epicondyle.[19,36]

Injuries to both the MPFL and the medial retinaculum are commonly discovered in patients with acute lateral patellar dislocation (the medial retinaculum is closely related to ligamentous MPFL midsubstance structure, as described later).[1,5,12,25,31] Although some studies have concluded that between 75% and 100% of MPFL disruptions are located in the femoral attachment,[1,5] others have reported figures up to 50% at the midsubstance[12,25] or patellar region,[12] depending on the classification. The MPFL is estimated to contribute an average of 50% to 80% of the restraining force against lateral patellar displacement.[7,9,16] This finding was supported by Hautamaa et al,[16] who found an increase of 50% in lateral patellar displacement after the MPFL function was eliminated. Repair of the MPFL restored lateral displacement to within-normal values, and further repair of other retinacular structures provided no additional stability in their study.[16]

The clinical relevance of MPFL injury after primary patellar dislocation has not been studied. Nomura[25] categorized MPFL injuries into 2 groups: avulsion tear and substantial tear. Medial patellofemoral ligament injuries have been further classified into 3 regions: the MPFL at the level of its patellar insertion, the MPFL (and medial retinaculum) at its midsubstance, and the MPFL at its femoral origin, as assessed from transverse MRIs.[12,33] Although the potential benefits of initial surgical repair of these MPFL injuries in stabilizing the patella have not been established, several MPFL reconstruction techniques have been described.[1,11,20,32] As based on biomechanical studies, the evidence suggests that the MPFL provides the critical soft tissue restraint against lateral patellar translation; as such, we designed a retrospective study of primary traumatic patellar dislocations in young adults. Our hypothesis was that the MPFL injury location may predict different prognosis and that the healing capacity for stabilizing the patella after identical nonoperative treatment may vary according to the MPFL injury location. In addition, we evaluated the possible chondral lesions occurring at the primary event, their relation to the MPFL injury, and the overall outcome after nonoperative treatment.

MATERIALS AND METHODS

Patients

This study focused on cases that can be defined as acute traumatic physical injury resulting in a first-time (primary) patellar dislocation. The main inclusion criterion was acute primary traumatic patellar dislocation confirmed by physical examination by an orthopaedic surgeon and by MRI (within 21 days from injury). We excluded all patients with a history of previous patellar dislocation or subluxation. In addition, the purpose of this study was to investigate long-term nonoperative healing of the injured MPFL; thus, we excluded patients who had had patellofemoral surgery of any kind (ie, any realignment procedure—open or arthroscopic, proximal or distal) during the first 6 months after injury. Patients with multiligamentous knee injuries and other previous traumas or major complaints of the knee joint were excluded as well. Also, nontraumatic situations, such as dislocation during normal gait or squatting or dislocation without forceful knee stress, were excluded because patients with spontaneous subluxation or patellar dislocation without immediate knee pain usually have pathologic laxity of the patellofemoral joint and a history of knee complaints since childhood or adolescence.

Because of the high occurrence of osteochondral injuries associated with primary traumatic patellar dislocations, we decided to not exclude patients who had undergone diagnostic arthroscopy or initial arthroscopic removal of an osteochondral fragment without any patellofemoral surgery or other restraint interventions. Arthroscopy performed either for diagnosis or for removal of a loose osteochondral fragment was thus not an exclusion criterion. All other surgical procedures were excluded, including open or arthroscopic procedures of an osteochondral fragment requiring fixation. Most of the traumatic dislocations occurred during sports activity or exercise, and the patients were almost immediately admitted to a hospital afterward because of acute knee pain. The management of primary traumatic patellar dislocations in the study hospital was not restricted to operative or nonoperative treatment; those who were surgically treated usually had an osteochondral fracture.

In addition to stipulating the above criteria, we expected all participants to complete the initial nonoperative treatment. The rehabilitation protocol of the hospital included a knee joint motion restriction period of 6 weeks with patellar orthosis; that is, the affected knee joint was allowed to progress to 30° of flexion in the first 3 weeks—after which, the movement was allowed to reach 60° of flexion. Immediate full weightbearing was allowed, and the study hospital provided a rehabilitation program with muscle-strengthening exercises under a physiotherapist's supervision, usually 2 to 4 months after the incident. The patient was expected to have completed a recovery period between 4 and 6 weeks (median, 4.5; range, 4-6), during which a patellar orthosis was worn.

To identify candidates for our study, we used our hospital discharge register database and, in doing so, identified 163 patients hospitalized between January 1, 1997, and December 31, 2002, with a dislocated patella and the appropriate diagnosis code, per the 10th revision of the International Classification of Diseases (ie, S83.0 of the ICD-10). We reviewed their medical records from the day of their admission to the hospital until their completion of the first 6 months of control visits at the same hospital. The Institutional Review Board accepting the protocol of this study was the Medical Ethics Committee of the study hospital, and a written consent was obtained from all patients.

At the time of injury, our hospital policy stipulated that initial management of traumatic patellar dislocation not be restricted to a specific form of treatment (surgical or nonsurgical), mainly because of the lack of supportive evidence. Those who were treated surgically usually had an osteochondral fracture; otherwise, the decision to operate was based on the discretion of the surgeon. After careful reconsideration of the medical records by 2 of the authors (P.S. and V.M.), 92 acute patellar dislocations were found with initial surgery, and 71 acute patellar dislocations were found without any patellofemoral surgery performed during the first 6 months after the incident. Of the 71 latter patients, 53 met all the inclusion criteria—that is, they sustained a first-time patellar dislocation (as confirmed by medical records and MRI) and they completed supervised aftercare (as confirmed by documentation)—and were thus enrolled into the follow-up study.

All enrolled patients were male recruits with a mean age of 20 years (range, 19-23) at time of injury. For the purpose of this study, we invited all 53 patients who met the inclusion criteria to a follow-up examination, or to fill out a postal questionnaire if a visit was not possible. The clinical assessment at the follow-up was made by the first author. Forty-two of the 53 patients participated in the follow-up: 32 attended the physical examination and control MRI, performed at a minimum of 4 years (mean, 7; range, 4-10) postoperatively, and 10 participated by returning the questionnaire. The number of subsequent redislocations, subjective instability (painful subluxation), and other problems were elicited and recorded. For subjective assessment of symptoms and functional outcomes, we used the patellofemoral scoring scale by Kujala et al,[18] with a maximum possible score of 100 points (ie, no symptoms). A score of 95 points or more was considered excellent; 94 to 85, good; 84 to 65, fair; and 64 or less, poor. A 100-mm visual analog scale (0, no pain; 100, most severe pain) was used to determine the patient's subjective pain in the affected knee. Physical activity levels were assessed on the Tegner scale,[35] with 0 denoting severe disability and 10 indicating a national- or international-level competing athlete. Patients were also asked whether they had regained their preinjury level of activity by follow-up.

Magnetic Resonance Imaging

During the study period (1997-2002), MRI was routinely performed at our hospital soon after any kind of knee injury, including all cases of traumatic patellar dislocation, with the purpose of ensuring correct diagnosis, excluding other intra-articular traumas, and defining possible injuries to the medial restraints. All patients enrolled into the study had undergone MRI within 21 days after the injury. As shown by our hospital register, 140 of the 163 patients admitted with acute patellar dislocation underwent an initial MRI during the study period, thereby indicating that no significant patient selection bias in MRI occurred. The MPFL injury location was assessed on both coronal and sagittal images and divided into 3 regions, as described by Elias et al[12]: the MPFL at the level of its patellar insertion, the MPFL (and medial retinaculum) at its midsubstance, and the MPFL at its femoral origin. As Elias et al described, the MPFL was visualized as low-signal-intensity fibers arising between the region near to the adductor tubercle and the medial epicondyle of the femur (Figure 1),

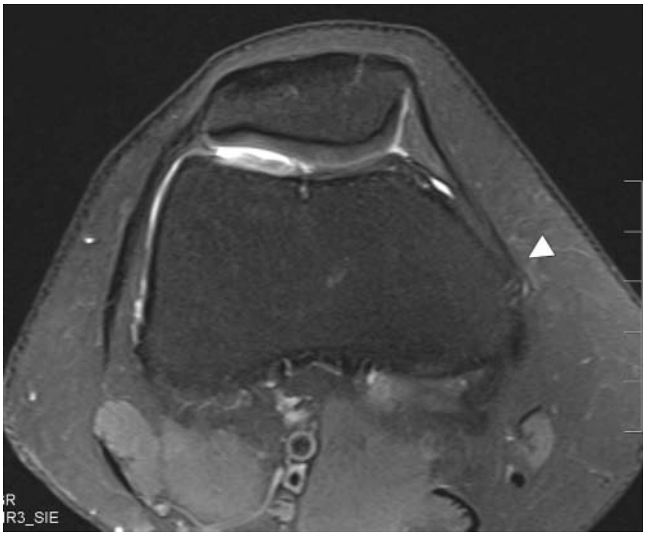

Figure 1. A transverse T2-weighted fast spin-echo MRI of the knee, obtained immediately inferior to the adductor tubercle. Arrowhead indicates normal medial patellofemoral ligament femoral insertion.

running just inferior to the inferior border of the vastus medialis obliquus muscle, and passing forward and inferiorly toward the medial patella. Complete disruption was defined as fibers in the expected region of the MPFL being completely discontinuous (Figures 2-4) or appearing absent with extensive surrounding edema. The MPFL was considered partially disrupted when some fibers were identified but with partial discontinuity, marked irregularity of fiber contour, and/or intraligamentous or extensive periligamentous edema. Regarding the primary disruption location, usually only a single MPFL location with total disruption was seen in each knee; sometimes, additional partial discontinuity was detected.

To reassess the initial MPFL injuries, all MRI images were independently reviewed by 2 musculoskeletal radiologists (M.K., E.P.), with 10 and 3 years of experience, respectively, who had not been involved with the treatment and were blinded to the original interpretation of the images and the follow-up results. The radiologists were also blinded to each other's interpretations, and in case of discrepancy, the images were reviewed again to reach a consensus. The radiologists were asked to determine the location of the main ligamentous disruption of the MPFL and to record any other visible partial disruptions. The MRIs were obtained using a 1.0-T MRI scanner (Signa Horizon, GE Medical Systems, Milwaukee, Wisconsin) and a dedicated knee coil. Slice thickness was 3 mm, with a 0.5- or 1.0-mm intersection gap. The routine sequences were as follows: sagittal T2-weighted fat saturated and proton density, coronal T1-weighted and proton density fast, and axial T2-weighted fat saturated and proton density fat saturated. In every patient, a primary MPFL disruption location was identified. None of the cases showed 2 independent locations with total discontinuity of the MPFL fibers.

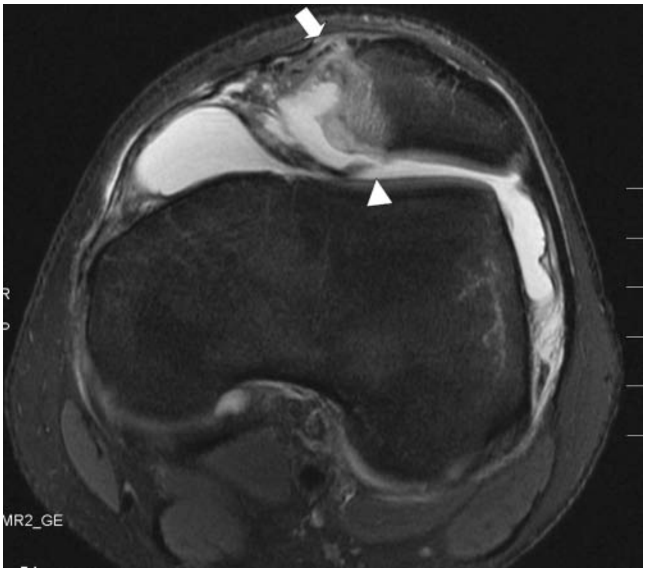

Figure 2. A transverse T2-weighted fast spin-echo MRI of the knee, obtained at the level of the superior pole of the patella demonstrates a complete disruption of the medial patellofemoral ligament patellar insertion (arrow) in a 22-year-old male patient 2 days after a primary traumatic lateral dislocation of the patella. Note the osteochondral fracture (arrowhead) on the medial patella; also note the excess fluid due to hemarthrosis.

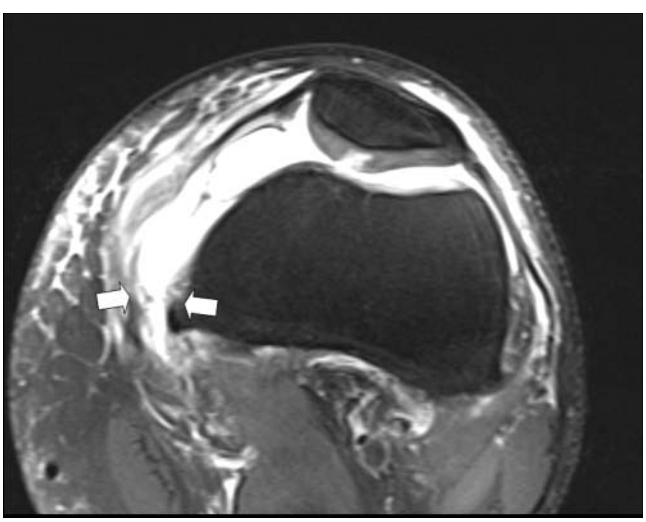

Figure 3. A transverse T2-weighted fast spin-echo MRI of the knee, obtained at the level of the medial patellofemoral ligament femoral insertion in a 20-year-old male patient 2 days after a primary traumatic lateral dislocation of the patella. Arrows indicate complete avulsion of the medial patellofemoral ligament off its femoral insertion in the knee.

In addition, plain radiographs of the patellofemoral joint were obtained in every patient, including posteroanterior, lateral, and patellofemoral axial radiographs. The parameter measured on the axial views included the sulcus angle, as described by Brattstroem,[3] with a measurement greater

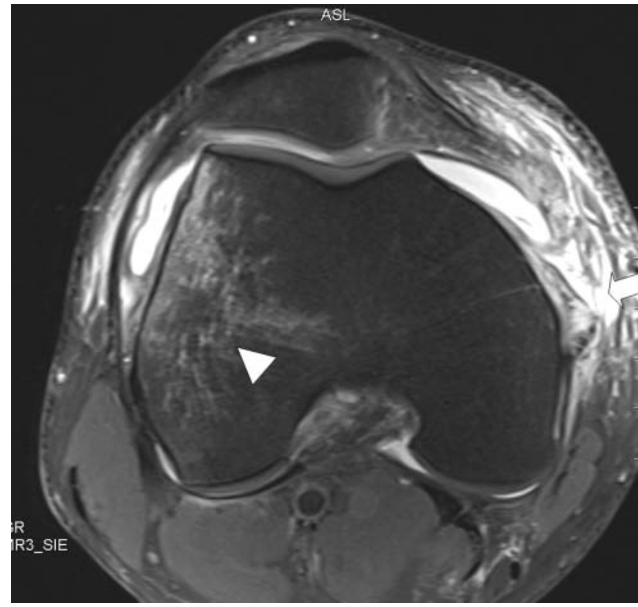

Figure 4. A transverse T2-weighted fast spin-echo MRI of the knee obtained at the level of the medial patellofemoral ligament femoral insertion in a 21-year-old male patient 2 days after a primary traumatic lateral dislocation of the patella. Arrow indicates complete disruption of the medial patellofemoral ligament at its midsubstance. The arrowhead marks a large bone contusion of the lateral femoral condyle.

than 150° representing trochlear dysplasia. Patellar height was measured on the lateral views so that a Blackburne-Peel[2] ratio greater than 1.06 was considered as patella alta. To measure the clinical Q angle, superimposed MRIs at the level of the tibial tubercle and the femoral trochlear groove[37] were obtained to assess tibial tubercle–trochlear groove distance, as described by Dejour et al[8]; values exceeding 20 mm were considered an abnormal Q angle.

At final follow-up, 32 of the 42 patients underwent a control MRI for assessment of chondral lesions. The same 2 musculoskeletal radiologists reviewed the images. The chondral lesions were classified according to their depth using the numeric grading system developed by the International Cartilage Repair Society and described by Brittberg and Winalski.[4] Grade 1 lesions were excluded because of the difficulties in differentiating these lesions from normal (grade 0) cartilage on MRI.[4] Because previous studies have shown MRI to be unreliable in detecting superficial lesions (softening),[10,15,17] only grade 2 to grade 4 lesions were documented, to avoid false-positive MRI findings. Grade 2 describes articular cartilage defects extending down to less than 50% of cartilage depth; grade 3, extending deeper than 50% of cartilage depth; and grade 4, defects with full-thickness articular cartilage loss.

Statistical Methods

The Kruskal-Wallis test was used to test differences in the nonparametric ordinal data; the independent samples t test was used to determine differences in the continuous,

TABLE 1
Patient Characteristics and Radiological Findings According to Location of Medial Patellofemoral Ligament Injury in Traumatic Primary Patellar Dislocation[a]

	Injury Location			
	Femur	Patella	Midsubstance	Total
Number of patients	35	7	11	53
Age at time of injury, years	20.0 (19-22)	20.2 (19-23)	20.3 (20-21)	20.0 (19-23)
Age at follow-up, years	26.9 (23-31)	27.1 (25-33)	27.0 (25-31)	27.0 (23-33)
Follow-up time, years	6.9 (4-10)	6.9 (6-10)	6.7 (5-10)	6.9 (4-10)
Hemarthrosis, %	60 (15-110)	55 (20-90)	60 (15-110)	50 (15-110)
Interval to MRI from trauma, days	3 (0-21)	4 (0-21)	5 (1-21)	3 (0-21)
Additional medial patellofemoral ligament injury[b] locations:				
Partial femoral tear	Not possible	1/7	6/11	
Partial patellar tear	13/35	Not possible	6/11	
Sulcus angle, degrees	142 (126-153)	142 (135-147)	143 (129-153)	142 (126-153)
Abnormal values given above the measurements	2	0	3	5/53 (9%)
Blackburne-Peel ratio	1.00 (0.83-1.21)	0.93 (0.69-1.11)	0.97 (0.87-1.10)	0.99 (0.69-1.21)
Abnormal values given above the measurements	8	1	2	11/53 (21%)
Tibial tubercle–trochlear groove distance, mm	12.7 (5-22)	13.3 (7-19)	16.9 (11-23)	13 (5-23)
Abnormal values given above the measurements	1	0	3	4/53 (8%)

[a]Major injury location divided into 3 regions and assessed by 2 radiologists in consensus. Values presented in means (and ranges), unless stated otherwise.
[b]Location of partial disruptions recorded (besides main medial patellofemoral ligament disruption).

normally distributed data—specifically, in the tests between the injury locations. Differences in the 2-way tables were determined with the Pearson chi-square test or with the Fisher exact test, when appropriate. Because the chi-square test is not reliable if the expected values are small (as was the case in injury locations other than femoral MPFL), further testing to localize a significant finding was performed using either a subset of the original 6-cell table (femoral, midsubstance, and patellar locations) or the 2 × 2 table statistics (femoral location compared with any other location) with the Fisher exact test. Significance was set at $P \leq .05$, and SPSS 14.1 for Windows (SPSS Inc, Chicago, Illinois) was used for the statistical analysis.

RESULTS

Of the 53 patients, 35 had femoral MPFL avulsions, 11 had midsubstance MPFL disruptions, and 7 had patellar MPFL disruptions (Table 1). Of the 42 patients who participated at follow-up, 25 had MPFL disruptions in the femoral region, 11 in the midsubstance region, and 6 in the patellar region (Table 2; see also, Figures 2-4). Overall patellar instability (including redislocation and painful subluxation) was significantly associated with femoral MPFL avulsion. In the femoral MPFL avulsion group, 13 of the 25 patients reported unstable patellae, compared with 1 of 11 in the midsubstance group and 1 of 6 in the patellar group (P = .01). There were 8 subsequent patellar redislocations in the femoral group (as documented by an emergency visit to a physician), compared with 1 redislocation in the midsubstance group and 0 in the patellar group (P = .05). Given the final follow-up results, the patellae of 6 patients who reported subsequent patellofemoral stabilizing operations owing to patellar redislocation (5 in the femoral group and 1 in midsubstance group) were considered unstable after initial nonoperative management (Table 2).

Preinjury activity level was best regained in the midsubstance region group (9 of 11), followed by the patellar region group (4 of 6) and the femoral region group (13 of 25). When the femoral region group was compared with the other groups, a significant correlation was found in not regaining preinjury activity level (P = .05). The median follow-up Tegner activity scores were as follows: 5 for the femoral group (range, 3-8), 6 for the patellar (range, 4-7), and 5 for the midsubstance (range, 2-7; P = .32). The overall subjective outcomes were not related to MPFL injury location. The median Kujala scores for subjective symptoms and functional outcome were as follows: 90 for the femoral region (range, 76-100), 91 for the patellar (range, 59-100), and 96 points for the midsubstance (range, 68-100; P = .76). When we excluded the 5 patients with femoral MPFL injury who later underwent stabilizing surgery, the median Kujala score for the 20 remaining patients in the femoral group was 85 (range, 76-100), compared with 94 (range, 59-100) for the patients with MPFL injury in the midsubstance and patellar regions (P = .59).

Based on MRI, an additional MPFL injury location was identified in 45% of the patients (24 of 53)—namely, a primary MPFL disruption location and partial MPFL tear in a different location. There were no cases of 2 separate total MPFL disruptions in the same knee. The presence of an additional MPFL injury location was not associated with increased patellar instability (P = .12). Initial osteochondral fractures were seen in 28% of cases (15 of 53), but they

TABLE 2
Results of the Functional Follow-up Examinations According to Location of Medial Patellofemoral Ligament Injury[a]

	Injury Location			
	Femur	Patella	Midsubstance	P
Patients	35	7	11	
With follow-up	25/35 (71%)	6/7 (86%)	11/11 (100%)	
Redislocation	8/25 (32%)	None	1/11 (9%)	.05[b]
Overall instability[c]	13/25 (52%)	1/6 (17%)	1/11 (9%)	.01[b]
Kujala score (max 100 points), median (range)	90 (76-100), 85 (76-100)[d]	91 (59-100)	96 (68-100)	.76
Excellent (95-100 points)	8/25 (32%)	2/6 (33%)	6/11 (55%)	.32
Good (85-94 points)	10/25 (40%)	4/6 (66%)	3/11 (27%)	.81
Fair (65-84 points)	6/25 (24%)	None	2/11 (18%)	.70
Poor (64 or less points)	1/25 (4%)	None	None	1.00
Tegner activity level (1-10)	5 (3-8)	6 (4-7)	5 (2-7)	.32
Regain preinjury activity level	13/25 (52%)	4/6 (67%)	9/11 (82%)	.05[b]
Visual analog scale (0-100 mm)	10 (0-70)	10 (0-50)	10 (0-20)	.96
Subsequent surgery	5/25 (20%)	None	1/11 (9%)	.39

[a]Major injury location divided into 3 regions and assessed by 2 radiologists in consensus. Values presented in sample size, n (and either range or proportion, as indicated).
[b]Considered significant ($P \leq .05$) when femoral medial patellofemoral ligament injury was compared to patella and midsubstance injuries.
[c]Overall instability including subjective symptoms of patellar instability (multiple subluxations).
[d]A subset of patients who did not undergo later stabilizing surgery, the median Kujala score for the remaining patients in the femoral group.

did not predict subsequent instability (P = .74). Large fractures requiring fixative surgery were excluded. The occurrence of osteochondral fractures was not related to any MPFL injury location (P = .97). Distributions of the initial chondral lesions showed no statistically significant differences between the MPFL injury locations (Table 3).

In radiographic measurements at the time of dislocation, 5 of 53 patients had abnormal trochlear groove, 11 patients had patella alta, and 4 patients had increased tibial tubercle–trochlear groove distance. However, as the summarized findings in Table 1 indicate, the majority of values in each MPFL injury group were normal. Between patients with or without recurrent patellar instability, no significant differences in radiographic measurements were found (Table 4).

At follow-up, full-thickness articular cartilage lesions, as signs of patellofemoral osteoarthritis development, were frequently found—specifically, in 45% of cases at the medial or lateral patellar facets and in 31% of cases at the articular surface of the femoral trochlear groove. This finding was unrelated to the MPFL injury location. Similarly, the presence of osteoarthritis characteristics was not associated with poor results in Kujala scores, and patellar instability was not significantly more frequent in patients with initial osteochondral fracture when compared with patients without osteochondral fracture (Table 3).

DISCUSSION

The principal finding of the present study was that MPFL avulsion at the femoral attachment in primary traumatic patellar dislocation predicted subsequent patellar instability. A significantly lower proportion of patients with femoral avulsion–type MPFL injury regained their previous activity level, as compared with patients with MPFL disruption in the midsubstance or patellar region. However, no differences were found in subjective scores between the injury locations. Although many studies have reported MPFL injury to be closely related to primary patellar dislocation, this study is the first to our knowledge to explore the clinical relevance of the anatomical location of MPFL injury after primary traumatic patellar dislocation. Thirteen of the 15 patients who had subsequent patellar instability after the primary incident suffered MPFL rupture at its femoral attachment, thereby indicating a significant relationship between patellofemoral instability and a femoral avulsion–type MPFL injury. As such, we suggest that the anatomical location of MPFL injury be taken into account when planning treatment for primary traumatic patellar dislocation.

Previous biomechanical studies suggest that the procedures that are intended to restore the normal passive limits against lateral patellar motion should include the repair or the reestablishment of the integrity and function of the MPFL.[13,16] Given the present study, we conclude that femoral avulsion of the MPFL is strongly associated with subsequent patellar instability, if stabilizing procedures are not performed. Ruptures at the MPFL midsubstance or patellar insertion regions were not related to subsequent instability, nor was the presence of primary disruption and additional partial MPFL tear. We therefore suggest that a rupture of the MPFL at its midsubstance or at its patellar attachment can be successfully treated nonoperatively, with infrequent subsequent symptoms of patellar instability. Furthermore, a nonoperatively treated femoral avulsion of the MPFL may result in some potential lengthening

TABLE 3
Distribution of MRI-Detected Articular Cartilage Lesions in the Medial Patellofemoral Ligament Injury Locations[a]

	Injury Location			
	Femoral	Patella	Midsubstance	Total
Initial chondral lesions / patella[b]				
Grades 2-3	13/35 (37%)	3/7 (43%)	7/11 (64%)	23/53 (43%)
Grade 4	None	None	None	
Initial chondral lesions / femur[b]				
Grades 2-3	8/35 (23%)	1/7 (14%)	1/11 (9%)	10/53 (19%)
Grade 4	None	None	None	
Initial osteochondral fracture[c]	10/35 (29%)	3/7 (43%)	2/11 (18%)	15/53 (28%)
Follow-up chondral lesions / patella[b]				
Grades 2-3	4/19 (21%)	2/5 (40%)	3/8 (38%)	9/32 (28%)
Grade 4	7/19 (37%)	2/5 (40%)	4/8 (50%)	13/32 (41%)
Follow-up chondral lesions / femur[b]				
Grades 2-3	2/19 (11%)	1/5 (20%)	1/8 (13%)	4/32 (13%)
Grade 4	7/19 (37%)	1/5 (20%)	2/8 (25%)	10/32 (31%)

[a]Major injury location divided into 3 regions and assessed by 2 radiologists in consensus.
[b]MRI-detected chondral lesions in the patellofemoral joint (at medial or lateral facets of the patellar articular surface or the femoral trochlear groove articular surface) including grades 2 to 4 (grade 1, superficial fibrillation only, excluded because of insensitivity of MRI detection). Classification according to depth using the numeric grading system developed by the International Cartilage Repair Society.[4]
[c]Initial osteochondral fracture detected by MRI.

TABLE 4
Radiographic Findings in Patients With Stable or Unstable Patellae, Final Follow-Up

Measure	Stable Patella Median (Range)	Unstable Patella Median (Range)	P
Blackburne-Peel ratio	0.99 (0.84-1.21)	1.00 (0.69-1.17)	.94
TT-TG distance,[a] mm	13 (8-23)	15 (5-22)	.12
Sulcus angle, degrees	143 (129-153)	142 (126-149)	.34

[a]Tibial tubercle–trochlear groove distance.

or loosening of the MPFL ligament (as in collateral ligament injuries of the knee) and in subsequent patellar instability. Therefore, if initial surgery is considered, it should be targeted at repairing the femoral MPFL avulsion, and reconstructive surgery should be aimed at restoring the integrity of the anatomical femoral attachment of the MPFL to ensure better stability. The increased Q angle and other major dysplastic features of the patellofemoral joint should be observed. A recent prospective randomized study by Palmu et al[27] on acute patellar dislocations in children and adolescents failed to prove the superiority of initial medial repair over nonoperative treatment for later patellar instability. However, contrary to our study, nearly all of Palmu's patients exhibited dysplastic features of the patellofemoral joint. In a prospective randomized study, Nikku et al[24] found no difference in outcome scores or instability rates between operative and nonoperative management of the primary dislocations. A recent prospective study comparing initial arthroscopic stabilization and nonoperative treatment for primary traumatic patellar dislocation also revealed unimproved patellar stability; yet, a better regain of preinjury activity level was noted.[33] Another recent prospective randomized study—this one of delayed femoral reinsertion of the MPFL, compared with nonoperative management—described no surgery-related benefits.[6] However, the investigators did not assess the MPFL injury location, and they used the same femoral reinsertion method for all their surgical cases.

This study has several limitations, the first being its retrospective nature. However, by reviewing the clinical and radiological examinations, we attempted to verify that the traumatic dislocation was primary and that the initial management had been identical in all patients. Second, owing to the lack of female patients, conclusions should be drawn with caution concerning the clinical prognosis of primary traumatic patellar dislocation in women. Also, because osteochondral fractures requiring fixation sometimes occurred near the patellar MPFL attachment and so acted as bony MPFL avulsions, we may have lost some MPFL injuries in the patellar region. These cases were not included in this study because the fixation procedure itself or the possible failure of the procedure might have affected the final results and because the misplaced fragment can produce patellofemoral pain. Exclusion of the large fragments suggests that the occurrence of osteochondral fractures (28%) might be somewhat lower than that among previous studies regarding traumatic primary patellar dislocations.[31,34] The strengths of the study include the homogeneity of the patients—that is, all were young healthy male adults, which resulted in good comparability between the individuals. Also, our enrollment was limited to patients with acute primary dislocations who had identical aftercare provided by the same hospital and under the same physiotherapist's guidance. In addition, in our opinion, the findings are quite generalizable to members of the standard young adult male population who sustain primary traumatic patellar dislocations during various physical activities, as compared with reports on athletic study populations selected from single-sport databases.[14,31]

Injuries to the MPFL and the medial retinaculum (a definition widely used in the literature before recognition of the MPFL injury) have been frequently reported in association with an acute lateral patellar dislocation.[1,29,31,34] Various authors have studied the anatomical locations of MPFL injuries. Avikainen et al[1] reported that in all 14 patients who underwent surgical exploration for acute patellar dislocation, the MPFL was avulsed from its femoral attachment. Sallay et al[29] reported an avulsion of the MPFL from the adductor tubercle in 94% of the knees in 23 patients with acute primary patellar dislocation. Burks et al[5] reported a simulation of patellar dislocation by comparing MRI findings and gross anatomical findings in 10 cadaveric knees; the MPFL was found injured in 8 knees, most commonly at its femoral origin. Elias et al[12] reported MRI findings of medial retinacular and MPFL injuries in 81 patients with acute lateral patellar dislocation. Although a medial retinacular structure was visualized in all patients, an MPFL injury was visualized in only 87% of the cases (76% at patellar insertion, 30% at midsubstance, 49% at femoral origin, and 55% in more than 1 site). This low incidence might be due to the long interval between dislocation and MRI (8 weeks). The same categorization of MPFL injuries was used in a recent prospective study in which the MPFL injury sites were 57% femoral, 23% midsubstance, and 20% patellar.[33] Nomura[25] reported the surgical findings of 67 knees (18 acute and 49 chronic patellar dislocations): Among the 18 acute dislocations, avulsion or detachment of the ligament from the epicondyle was evident in 7 knees; a midsubstance-type tear was present in 10 knees, with a tear of the MPFL found typically near its femoral attachment; and in 1 patient, the ligament was loose yet without a discrete injury. Sanders et al,[30] comparing surgical results with MRI, reported an MPFL injury in all 14 patients and concluded that MRI is an accurate method for depicting MPFL injuries.

The nonoperative treatment method used on our patients aimed to prevent further loss of integrity of the injured MPFL. It is not known whether knee flexion restriction prevents the MPFL lengthening.[7,9,16] In the case of femoral avulsion of the MPFL, however, the ligament may fail to heal altogether because of the loss of integrity of the ligamentous structure. Whether the knee should be immobilized in nearly full extension to prevent further loosening of the MPFL femoral attachment is unknown[21,23]; at the very least, it demands considerable compliance by the patient to accept immobilization for 3 to 6 weeks (splint or cast). However, in this study, some MPFL ruptures in the femoral region healed to produce reasonable patellar stability, but there was no evidence of any MRI-specific finding that predicted this phenomenon.

Although we found that initial patellofemoral articular cartilage injuries were common, they were unrelated to a MPFL injury site. In the present study, initial osteochondral fractures were not associated with recurrent patellar instability, although authors of previous studies have suggested operative management of primary dislocations with osteochondral fracture.[34] Our findings suggest that dislocation with an osteochondral fracture requiring surgical intervention may benefit from MRI assessment, to enable localization of a possible MPFL disruption and to decide on concurrent stabilizing repair or reconstruction surgery. Furthermore, given that previous studies have described good comparability between MRI findings and surgical findings in MPFL injuries,[26,30] no surgical exploration of MPFL injury location might be necessary if initial repair or reconstruction is chosen. In the present study, MRI revealed frequent osteoarthritis characteristics at follow-up, but these were unrelated to the MPFL injury site. The number of patients with patellofemoral osteoarthritis was consistent with earlier research.[22]

In conclusion, this study provides strong evidence that MPFL avulsion at the femoral attachment in primary traumatic patellar dislocations predicts patellar instability. The MPFL has been defined as the critical soft tissue restraint against lateral patellar translation. Hence, residual laxity in the femoral region of the MPFL might be responsible for the frequent subsequent patellar instability reported after primary patellar dislocation. Our findings indicate that the outcomes after MPFL rupture vary according to the rupture location; in patients with a disruption at the midsubstance or at the patella, recurrent instability seems significantly less common than in patients with an avulsion of the MPFL in the femoral region. Even when MPFL avulsion at its femoral attachment is accompanied by a partial MPFL tear in the midsubstance or patellar region, no additional risk for instability is predicted. Consequently, the findings may be helpful in planning treatment modalities; that is, initial stabilizing surgery might be considered when femoral MPFL avulsion has occurred in a high-demand patient who requires good patellar stability, whereas initial surgery cannot be recommended for midsubstance or patellar MPFL ruptures. However, because the subjective scores were the same between the study groups, our results deserve further prospective investigations to ascertain the clinical significance of the MPFL injury location, particularly in terms of whether surgical stabilizing interventions are superior to nonoperative healing and reestablishment of the critical restraint function of the MPFL in certain injury patterns.

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